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ROCKY MOUNTAIN MASS CONCRETE
OPERATIONS

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CONSTRUCTION DIVISION

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ROCKY MOUNTAIN MASS CONCRETE OPERATIONS

George P. McIndoe

Rocky Mountain mass concrete operations consist chiefly of a primary crusher arrangement, aggregate screening plant, concrete batching plant, and a shuttle and cableway system. The plant is situated high in the Rocky Mountains adjacent to Boulder Creek Canyon at an elevation of 7300 feet, approximately thirty (30) miles from Denver, Colorado. The overall arrangement was selected and designed with an efficient and economical cableway operation first in mind. Considerable difficulties arose in locating the plant and equipment and access roads due to the hazardous mountain slopes and high wind velocities. These difficulties and the consequent plant arrangement will be discussed in some detail.

INTRODUCTION

The Macco-Puget Sound Construction Company, a joint venture between the Macco Corporation of Paramount, California, and the Puget Sound Bridge and Dredge Company of Seattle, Washington; entered into contract on June 1st, 1951, to construct Reservoir Dam No. 22, a gravity arch type dam, located on South Boulder Creek, Colorado, for the Denver, Colorado, Municipal Water Department. The dam, when completed, will be over 340 feet high, over 1000 feet long at its crest, and will contain some 588,800 cu. yds. of mass concrete.

To say simply that the concrete making operations at Reservoir Dam No. 22 are "quite unusual" is a generous understatement. Upon completion of design, various engineers and contractors sometimes described the location of this plant as "atop an ice-cream cone." The first question asked would inevitably be: "Why should these modern aggregate processing and batching facilities be situated on such a hazardous terrain?" As mentioned before, the plant location was based primarily on the location and operation of the cableway. The cableway was necessarily designed so that it required a minimum amount of excavation for its location, and at the same time gave sufficient coverage of the dam. Having established the position of the cableway on paper it was decided that the remaining plant should be placed adjacent to the cableway traveling tail tower, a hazardous undertaking, but the most practical nevertheless; especially with the following operational points in mind:

First, it proved economical to condense the primary crusher, aggregate screening plant, mixing plant, and cableway traveling tail tower into one area from the standpoint of operating labor and supervision; second, sufficient processed aggregate storage piles could be placed in the area so that mass concrete could be poured continuously on a three-shift basis, taking into account a normal amount of breakdowns in the screening plant; third, sufficient raw aggregate storage could be provided as a surge of supply for the screening plant, since slippery roads and difficult grades make hauling of raw aggregates an inconsistent operation; and fourth, the site was best adapted for procuring raw aggregates from the various sources in the general area.

RAW AGGREGATE MATERIALS

Investigations of South Boulder Creek, consisting of many test pit holes and quantity surveys, indicated that large amounts of natural river run aggregates were available. Analysis of many dozens of put samples indicated that the material was suitable for concrete aggregate. However, the results of these tests also showed that many problems would arise in processing aggregates which would meet the specifications required for this mass concrete operation. Some test pit holes showed that the material would very nearly fail to pass the Los Angeles Rattler Test Specification (10% at 100 revolutions). Test samples which showed traces of organic materials, mica particles, and clay pockets were found.

Screen analyses of the various test pits showed that there might be deficiency in cobbles (minus 6" - plus 3" rock) and in certain sizes of sands. Inasmuch as it was most difficult to analyze the overall gradation of the pit run aggregates, it was decided to remedy these probable deficiencies by augmenting all natural aggregates with a suitable crushed rock product. The specifications allow crushed rock for concrete aggregate in any given amount.

PLANT CAPACITY AND STORAGE REQUIREMENTS

Due to the relatively short pouring season, the high altitude, snow and rain, and contract completion date, it was decided that suitable aggregate storage should be provided to supply the concrete batching operations with sufficient capacity to pour on a six day - three shift basis at a pouring rate of 1800 cu. yd. mass concrete per day. In order to maintain this projected schedule, it was necessary to obtain an area to store 64,000 tons of processed material, of which 21,300 tons would be live storage. A raw storage of 18,000 tons was considered to be sufficient.

Commensurate with this operation, it was calculated that a suitable excavation, hauling, primary crusher and screening plant operating at 400 tons per hour for eight hours - and six days per week would be sufficient.

PLANT SITE

The exact location of the original plant site was determined by a study of mountain contours and passes with regard to the advisability of placing the plant adjacent to the right abutment (South side of the canyon). It was evident in the beginning that the contractors would have to provide access roads to both sides of the canyon, primarily for the purpose of removing rock excavation from the right and left abutments of the dam. These access roads could be used also for locating and constructing a suitable cableway. After many initial studies and preliminary surveys, it was found that these access roads could be constructed at a nominal cost. The more difficult problem, however, was the location of the plant site. Contour maps and other survey data were limited, the area was heavily timbered, and always there were the hazardous precipices of some 300 ft. to the river bottom. After making more extensive surveys, the Engineering Department of the Macco-Puget Sound Construction Company decided that the plant site location should be situated adjacent to the right abutment looking down-stream. Since the traveling tail tower of the cableway was also to be located on this side of the canyon, and the space available for any working area was greatly limited, the plant arrangement was necessarily very compact, and in several instances of unique design. Although

large quantities of excavation were required to place all of the plant in such a mountainous and limited area (6 acres), the overall design proved to be practical and economical.

RAW MATERIALS OPERATION, PRIMARY CRUSHER

The pit run materials are excavated from the river bottom by means of deisel power shovels equipped with 2 1/2 cu. yd. buckets and deposited into 12 to 16 cu. yd. capacity dump trucks. The loading operation is being handled with some care in order not to load boulders over 18" to 20" diameter. Larger boulders would have difficulty in passing through the primary crusher. The material is then hauled from these various aggregate sources to this primary crusher some three to five miles away, and is there dumped into a 30 cu. yd. capacity truck dump hopper.

The truck dump hopper is equipped at the bottom with a 36" wide by 8' long traveling pan feeder, which deposits the raw aggregate onto a stationary rail type grizzly with a six inch opening. The material passing the grizzly bars drops directly onto a 48" conveyor belt and is transported to the raw storage pile. The material retained on the grizzly bars passes into a 42" by 48" jaw type primary crusher, where it is reduced to minus six inch crushed rock and is deposited on top of the material passing the grizzly bars and in like manner transported to the raw storage pile.

FEED TO SCREENING PLANT

Underneath the raw storage pile is constructed a reinforced concrete feeder house approximately 8' by 12' and 8' high, designed for a total dead load of 6000 lb. per sq. ft. This housing is equipped with a pulsating electric pan feeder rated at 500 tons per hour, which is itself fed through an opening in the top of the concrete housing. The feeder deposits the minus six inch raw aggregate onto a 30" conveyor belt running at 450 ft. per minute and capable of handling 550 tons per hour. This conveyor belt transports the raw aggregate to the top of the screening plant. The amount of feed to the conveyor can be varied from 100 tons per hour to 500 tons per hour by means of a feeder rheostat located and operated at the screening plant some 200 feet away.

SCREENING PLANT

The screening plant design was used primarily with three objects in mind: the production of clean, well-screened and graded aggregates; the elimination of unsound and deleterious materials; and particularly the construction of a self-cleaning, operating plant to minimize operating and clean-up labor.

The screening plant building consists of a structural steel frame 24 ft. wide by 60 ft. long and 60 ft. high. The first major problem encountered in the design of the screening plant was that of supporting an 8 ft. diameter by 18 ft. long solid trommel. The trommel is necessarily located on the fourth floor of the screening plant some 50 ft. above the ground. The trommel itself rotates at 14 r.p.m. and is designed to pass 400 to 500 tons per hour of minus six inch aggregate.

The raw material enters the trommel from the 30" conveyor belt mentioned above. About 300 gallons of water per minute are injected into the mouth of the trommel along with the aggregate. Its two-fold purpose is to break up the unsound particles of aggregate and to clean and scrub the rock by its own abrasion.

The aggregate leaving the trommel is now deposited onto a five ft. by 10 ft. heavy duty two-deck scalping and dewatering screen. At this point four closed aggregate circuits begin: sand processing, rock sizing, crushed rock, and crushed rock materials for manufactured sand.

(a) Sand Processing

The bottom deck of the scalping and dewatering screen is equipped with special wedge type grizzly bars spaced at 3/16". Through this 5 ft. by 10 ft. bottom deck all the minus #4 sand and water pass and flow by way of a launder directly into a 14 ft. diameter hydroseparator. This hydroseparator is equipped with a slow speed, four blade traveling rake, rotation at 3 to 5 r.p.m. The action of the rake keeps the sand and water agitated, giving the sand ample time to drop from suspension. The hydroseparator is also equipped with a circular 14" by 14" overflow launder at the top, which carries off all of the waste water, organic and floating matter, and particularly the bulk of the minus #100 material which remains in suspension in the water. The waste water leaving the top of the hydroseparator goes directly to the main waste plant flume.

The bottom of the hydroseparator is cone shaped and is equipped with an 8" rubber pinch valve, which is the medium of control for regulating the passage of sand pulp at any desired water content. The adjustment of this pinch valve is one of the most critical operations of the sand circuit. The capacity of the hydroseparator under normal operation is designed for 100 to 125 tons per hour.

Since this sand passing through the pinch valve is now clean and free from almost all organic and floating materials, it now passes into a launder and is transported onto a single deck, 4 ft. by 10 ft. vibrating screen. This screen is of the short throw, pulsating type.

The single deck is equipped with a #16 wire mesh screen cloth. The sand is therefore, split into two definite gradations, and this splitting is accomplished with the aid of high pressure sprays directly on the screen. The sand which is retained on the top of the screen is now a minus #4 to plus #16 sand product, and under normal operation passes down a chute and onto an 18 inch conveyor belt--and thence directly to its respective storage pile. But in case the natural pit run sands should consist of excess coarse sand (#16 to #4), the material from the top deck of the above mentioned screen can be bypassed (any amount or all) to the sand manufacturing circuit (rodmill).

The through sand passing this #16 wire cloth now becomes #16 to #100 gradation, and flows directly by launders into the Sand Wheel for final dewatering.

The operation of the Sand Dewatering Wheel is based on a slowly revolving wheel set in a settling tank. The wheel is 10 feet in diameter and 6 feet in width. Twelve buckets form the outside diameter of the wheel. Each bucket is equipped with a set of overflow louvres, so that surface water can be removed by decanting; this first cycle is completed in 3 seconds. The second cycle lasts from 15 to 20 seconds, depending on speed of wheel. Water and sand are removed by vacuum through filtering brushes in buckets. Full length, round and flat brushes at bottom of the buckets allow air and water but not sand to be drawn through. The back of buckets are completely enclosed and connected to an automatic valve which permits air to be pulled through at proper cycle. The water drawn through brushes is collected in a vacuum tank and returned to main settling tank by a sand pump.

Vacuum is created by a 2500 to 3500 C.F.M. turbine air compressor,

mounted over a vacuum tank. The sand now becomes dry enough at this stage of the vacuum cycle to crumble and fall forward down its chute to the sand stacking conveyor.

The wheel operates at a speed of $1/2$ to $1\ 1/2$ R.P.M. depending on the dryness and tonnage required. The speed can be varied immediately as unit is equipped with a variable speed drive. The capacity for this wheel unit is 75 T.P.H. at $3/4$ R.P.M. for material containing practically no moisture. At 125 T.P.H. it is anticipated that the material will have $1\ 1/2$ to 2% moisture. Extreme dryness can be reached by processing 50 T.P.H. at $1/2$ R.P.M.

(b) Sizing of Aggregates

The material retained on the lower deck of the dewatering and scalping screen, a minus 6" plus #4 rock product, is transferred to a battery of four 4 ft. by 14 ft. double deck vibrating, rock sizing screens. Two of these screens compose a parallel, identical top bank and two compose a parallel, identical lower bank. The material from the dewatering screen is deposited onto the upper bank of sizing screens by means of a two-way pants-leg type chute, each leg being equipped with a control gate so that either or both of the upper bank of screens may be fed with rock at any time.

Each of the upper two sizing screens are equipped with - $3\ 1/4$ " opening wire cloth on the top deck and $1-5/8$ " opening wire cloth on the bottom deck. The material retained on the top deck is, therefore, a minus 6" plus 3" sized rock product; and the material passing the top deck, but retained on the bottom deck is a minus 3" plus $1\ 1/2$ " sized rock product. These aggregates fall into chutes and are deposited onto their respective stacking conveyors. The material passing the $1-5/8$ " opening bottom decks of the upper sizing screens is deposited into a collection hopper and then fed onto the lower bank of sizing screens. Each of the screens is equipped with $7/8$ " opening wire cloth on the top deck and $3/16$ " opening wire cloth on the bottom deck and therefore produce $1\ 1/2$ " to $3/4$ " sized rock and $3/4$ " to #4 sized rock (pea gravel) on the top and bottom decks respectively. In like manner these aggregates fall into chutes and are deposited onto their respective stacking conveyors.

The material passing the bottom decks of the lower bank of sizing screens is a minus #4 sand and is small in amount. It passes into a collection hopper and onto a stationary grizzly where the coarser sand is retained and directed to the sand pump, yet to be discussed. The material passing the grizzly is flumed to the main waste system.

All of the screens mentioned before are equipped with high pressure jet sprays, which, on the sizing screens, give the rock a third and final washing. The capacity of the sizing screens was chosen so that ample screening area would always be available. Further, in case of breakdown, the left two screens may operate independently of the right two screens, and vice versa.

(c) Crushed Rock Circuit

The top deck of the dewatering and scalping screen is a plate type screen. The upper half has $6\ 1/2$ " openings and the lower half has 6" and $5\ 1/2$ " openings. These openings can be arranged to scalp off varying amounts of plus 5" rock. This retained material is deposited into a heavy-duty chute and thence into a surge box, from which it is transferred into either of two gyratory type crushers.

The two gyratory crushers are of two distinct types. One is a 4 ft. low head type equipped with a fine grinding bowl, which produces a fine graded

product, particularly a rodmill feed product. The other is a 4 1/2 ft. standard gyratory type and is equipped with a coarse grinding bowl, adapted for producing coarse crushed aggregates in large quantities, if and when required. The product from these crushers is now deposited onto a 24" conveyor belt, which deposits the material onto a second conveyor belt. The second conveyor brings the crushed rock again to the top of the screening plant and deposits it onto two 4 ft. by 8 ft. double flat deck screens (by way of another pants leg type chute). The purpose of these screens is three-fold. First, the top deck is equipped with a 5/8" mesh wire cloth and the material retained on this deck is approximately 1 1/2" by 1/4" crushed rock. This material passes directly to the sizing screens and is screened again along with the natural river run aggregates, as before described.

Secondly, the material passing the 5/8" opening wire cloth and retained on the bottom deck (3/16" opening wire cloth) is necessarily a minus 1/2" plus 1/4" product, suitable for a sand manufacture process. This material is deposited into a two-way chute, and can be diverted either to the sizing screens or onto an 18" conveyor belt (for rodmill feed). This will be discussed later.

The third purpose of the flat deck screens is to reclaim all sand manufactured by the crushers. This minus #4 product passes the lower deck of each screen, falls into a collection hopper, flows into a launder (water is added), and is deposited into the hydroseparator for washing and sizing (along with the natural sands already discussed).

(d) Manufactured Sand

As mentioned before the minus 1/2" plus 1/4" rodmill feed product from the 4 ft. by 8 ft. flat deck crushed rock screens can be by-passed onto an 18" conveyor. This conveyor travels about 25 ft. and deposits the material into a 150 ton capacity storage bin located just outside the screening plant. The material from this bin flows by gravity through two openings at the bottom onto two reciprocating type feeders equipped with variable speed drives. These feeders deposit the material into each end of a 6 ft. by 12 ft. rodmill, where water is also added. The amount of feed and water is calibrated, so that any desired size of sand may be manufactured. The rodmill rotates at 15 r.p.m. and is charged with 25 tons of high carbon steel grinding rods.

The rodmill discharge is located in the center at the bottom. The manufactured sand product passes from this discharge into a surge box, where a 60 t.p.h. sand pump pumps the material through a 4" pipe line about 35 ft. up to the hydroseparator. Here the manufactured sand is blended with the natural sands and washed and sized as before discussed.

SUMMARY-SCREENING PLANT

The screening plant structure is only 24 ft. wide, 60 ft. long and 60 ft. high. Through carefully engineered arrangement, design capacities, and equipment supports, we were able to house a trommel, dewatering and scalping screen, two crushed rock screens, four sizing screens, a sand scalping screen, a hydroseparator, a sand dewatering wheel and the tail sections of six outgoing stacking conveyors. Further, the six aggregate products are well screened and washed.

STOCK PILES

As discussed before, it was determined that approximately 21,300 tons of

live processed aggregate storage would be required to provide ample surge for the concrete making operations. Because of the limited working area and the cone shaped mountain on which the plant site is located, the only feasible solution was a system of tunnels underneath the stock piles arranged in a "T" shape. The top of the "T" is oriented toward the mixing plant, and is underneath the minus 3/4" plus #4, minus 3" plus 1 1/2" and minus 6" plus 3" screened aggregate stock piles. The leg of the "T" is parallel to the screening plant and underneath the minus #16 plus #100 sand, minus #4 plus #16 sand, and minus 1 1/2" plus 3/4" screened rock stock piles. This arrangement was economical for two reasons: first, the 24" stacking conveyors (handling minus 6" plus 3", minus 3" plus 1 1/2", minus 1 1/2" plus 3/4" screened rock) are the three shortest conveyors, and the three 18" stacking conveyors (handling the fine sand, coarse sand, pea gravel) are the three longest conveyors; secondly, locating the minus 6" plus 3" and minus 3" plus 1 1/2" rock on the top of the "T" eliminates the necessity of transferring these large materials more than once, after they are in their respective stock piles. About 600 lineal feet of 18" conveyor and 380 feet of 24" conveyor were required to complete the stacking conveyor system; about 700 feet of corrugated multi-plate pipe were required for the tunnel arrangement.

The three 18" conveyors handling the two sands and pea gravel dump directly onto their stock piles, each pile being some 50 feet high. The three 24" conveyors handling the larger screened rock sizes deposit their loads into shelf type rock ladders some 55 feet high. Each rock ladder is supported on a reinforced concrete housing.

The corrugated multi-plate pipe tunnels house two 30" conveyor belts. The conveyor in the leg of the "T" deposits its load onto the conveyor in the top of the "T" part of the tunnel. This latter conveyor runs for some 780 feet to the top of the mixing plant.

Underneath each stock pile are two hand operated gates. These gates act as valves for the feeding of the rock above onto the conveyor belt in the tunnel. Each rock size is conveyed to the mixing plant separately-- that is, no blending of aggregates is done on the belts.

At the junction of the two tunnels is constructed a reinforced concrete structure 12 feet by 15 feet by 13 feet high. The dead load on the top of this junction house was taken at 5,000 lbs. per square foot, since this structure is necessarily located directly beneath the minus 6" plus 3" rock stock pile.

As indicated above, the stock pile system contains two piles of sand. One is fine sand (minus #16 plus #100) and the other coarse sand (minus #4 plus #16). The most important purpose of these two piles is to regulate the fineness modulus of the processed sand. It is quite probable that the natural pit-run sands will contain either too much or too little of the minus #4 plus #16 size at different times (different excavation locations), but the overall gradation of the natural sands should be within specifications. Therefore, the minus #16 plus #4 stock pile acts as a surge when coarser sands are being excavated, and the minus #16 plus #100 stock pile acts similarly when finer sands are encountered.

It was mentioned also that no blending would be done on the conveyor belt beneath the sand stock piles. Although this is common practice in concrete making, it is also an inaccurate and inconsistent process. Therefore it was decided to transport the fine sand and coarse sand to the mixing plant separately, where they could be weigh-batched and consistent results obtained.

CEMENT STORAGE

Bulk cement is delivered at the Crescent, Colorado railroad siding, about

3 1/2 miles from the mixing plant site. Here the Denver Water Board has installed a separate railroad siding for unloading bottom dump type cars. The cars are moved after switching with an electric car mover. Each car has a capacity of 400 bbl. of bulk cement. The cement flows by gravity from these cars into a screw type feeder underneath the track. The screw feeder deposits the cement onto an enclosed 18" by 60 ft. long conveyor belt, which in turn deposits the cement into a 1750 bbl. capacity storage bin. All of the above equipment was designed with the knowledge of frequent high wind velocities and necessity for moisture proof system especially in mind. The cement is now truck-hauled from the Crescent silo to a 4090 bbl. capacity silo adjacent to the mixing plant. Here it is deposited into a truck dump hopper, under which is located another screw feeder. This screw deposits the cement into a bucket elevator, which conveys it upward and dumps it into a chute connected to the top of the silo. The screw feeder mentioned above is oriented so that it can be used to convey cement from the bottom of the silo again to the bucket elevator. The bucket elevator again dumps the cement into the above mentioned chute, but by means of a butterfly valve the cement is directed to the mixing plant storage bin, instead of the silo, as before.

WATER SUPPLY SYSTEM

Water for aggregate manufacturing, concrete mixing and clean-up operations is supplied by four vertical turbine pumps mounted on a barge placed in a sump blasted in South Boulder Creek Channel. Each pump is powered by a 150 h.p. 440 v. motor and supplies 1000 gallons per minute and operates under a total head of 500 feet. The pumps are automatically controlled by floatless liquid level controls. Protection against surge is provided for each pump by installation of hydromatic check valves.

The four pumps are connected to a 25 ft. section of 10" rubber hose by means of a pipe manifold. The 10" rubber hose is in turn connected to a 10" steel pipe line leading to a 100,000 gallon storage tank placed above the screening and mixing plants. Total lift from pumps to storage tank is 430 ft. The rubber hose provides a flexible connection between the steel pipe anchored on the mountain side and the floating pumping station, and gives considerable latitude for variation in the water surface elevation of the river.

Mounting of the pumps on a barge was chosen as the most economical method, since it is anticipated that water storage in Reservoir No. 22 will begin early in the 1953 construction season and the water surface elevation will rise as construction of the dam permits.

In order to provide adequate working pressure for spray nozzles mounted over the vibrating screens, a booster pump is installed in the water service line at the screening plant. Design requirements called for a pump to supply 1100 gallons per minute under a differential head of 150 ft.

MIXING PLANT

The mixing plant for this job is a standard, fully automatic Johnson batching plant with a storage capacity of 500 cu. yds. of the six aggregate sizes and 300 bbl. of cement. The structure is 95 feet high with the storage bins located at the top; the six aggregate storage bins surround the cement storage bins located in the center. The aggregates are fed to these bins from the main 30" conveyor (described above) by means of a swivel type chute. The cement feed has been discussed previously.

The aggregates are fed from their respective bins by gravity into weigh batching hopper, each one being equipped with a separate scale and being operated automatically with solenoid valves and air rams, from the main control panel. The materials from the weigh-batching hoppers are next deposited into a mixing hopper where water and air entrainment are added. All of the materials are then dumped into two 4 yard revolving, tilting type mixers. Each mixer has a capacity of 7 cu. yds. per hour giving a total of 140 cu. yds. per hour at 2 1/2 minutes mixing time.

Some of the salient features of this plant are its air entrainment equipment, batching facilities, consistency metering operation, and batch by batch recording of cement usage per yard of concrete. All of the equipment mentioned above is fully automatic and controlled from a main panel by one operator.

When the concrete has mixed satisfactorily it is dumped into an 8 yd. capacity receiving hopper first from one mixer and then from the other. The 8 yds. of concrete are then deposited into an 8 yd. hopper on a flat car. The flat car is propelled along a dinky track with a diesel electric driven locomotive for a distance of 200 to 700 foot to the cableway setting. Here the concrete is released by means of an automatic air dumping device into an awaiting 8 yd. capacity concrete bucket, setting on a deck 14 feet below the dinky track - awaiting pick up by the cableway hook.

CABLEWAY

The general problems which the contractor faced with respect to cableway location and capacity have been discussed in some detail previously. Hence it remains only to describe the design and operation of the cableway.

The cableway is of the standard type with a stationary head tower 109 ft. high located on the north or left side of the canyon and a moveable tail tower 42 ft. high on the opposite side of the canyon. The head tower is supported on a concrete foundation and is guyed with two 3" diameter backstay cables and two 2" diameter front stay cables. Each backstay cable is jeweled into a socket which is bolted to two 4" diameter special steel anchor bolts, and these anchor bolts are imbedded into 115 cu. yds. of concrete. The front stay anchors are similarly connected to 60 cu. yds. concrete anchors.

The moveable tail tower travels on two of 112 lb. rail track on an arc approximately 550 ft. long. It carries concrete counterweight of 210 cu. yds. It is powered with a 100 h.p., 2200 v. induction motor and has a rated speed of 6 miles per hour.

The cableway span is 1730 ft. with the head tower main gut pin located at elevation 7500.0 and tail tower main gut pin located at 7387.0, a difference of 113 ft. All of the cableway operations are controlled from the head tower side. As discussed previously, the dinky track, along with the rest of the plant, is located on the tail tower side.

Five different cables are required for the actual operation of the cableway. First, there is the main gut, a 3" diameter lock coil type cable; a 6% main gut sag is being used in the present operation, giving a sag low point at elevation 7332 and a factor of safety of well over 3 for normal loads on the cable. A 40 ft. long carriage, from which the 8 cu. yd. concrete bucket is lowered and elevated travels along the main gut. Second, there is a 1" diameter endless line 4000 ft. long which moves the carriage back and forth. Third, there is a 7/8" diameter load line, also 4000 ft. long, which lowers and elevates the concrete bucket. Fourth, there is a "button line", which stretches from head

tower to tail tower. This line keeps the slack carriers, which receive the slack of the load line spaced. Fifth, there is a messenger line which supports flood lights for night operation.

The endless and load lines are operated from a two drum hoist located at the foot of the head tower and powered by a 500 h.p., 2200 v. motor. Both drums have a rated speed of 2900 ft. per min. Using a four part line, the hoisting speed for the concrete bucket is approximately 750 ft. per minute.

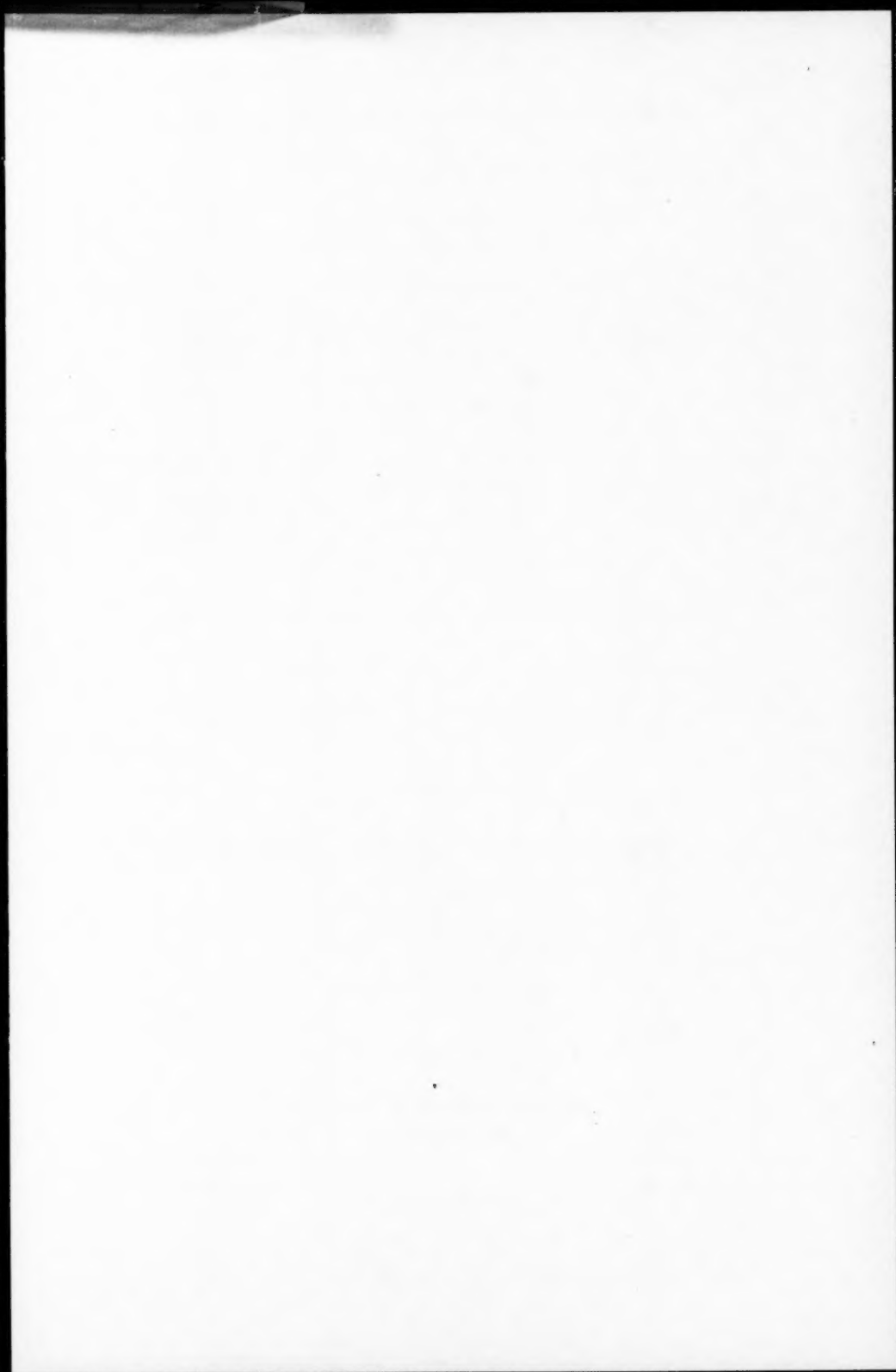
It is estimated that this cableway operation shall have a pouring rate from 100 to 120 Cubic Yards per hour using a 8-Cubic Yard Bucket.

CONCLUSION

In conclusion to the foregoing paragraphs, one may easily recognize the many problems confronting the Contractors in planning, design and operation of mass concrete production at elevation 7300 for construction of the highest Concrete Dam in the State of Colorado.

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268-12



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